Land Cover/Land Use Theme Planning
A Preliminary Needs Assessment

FINAL REPORT

To

MT Department of Administration/ITSD
Montana State Library- Natural Resource Information System/MSL-NRIS

Submitted by:

Linda Vance,
Ecologist/Spatial Analysis Lab Director,
The University of Montana
Montana Natural Heritage Program
February 13, 2008

INTRODUCTION

In November 2007, the Montana Department of Administration Information Technology Services Division and the Montana State Library entered into a contract with the University of Montana's Natural Heritage Program to conduct a preliminary needs assessment to determine what land cover product, products or functional applications would best meet the needs of Montana GIS users and decision-makers. The specific approach proposed in that agreement included the following steps:

1. Collect examples of land cover/land use layers and/or applications, including classifications, that have been developed in other states (e.g. Wisconsin, Illinois, Delaware, etc);
2. Assemble information on collaborative methods, funding mechanisms and data distribution channels used in those efforts;
3. Condense these examples and information into a succinct characterization of potential directions for theme development;
4. Working through the NHP Partners' committee and the state GIO and GIS coordinator, identify key decision-makers and theme end users in federal, state, and local governments, non-profits, universities and private enterprise in Montana;
5. Contact these targeted individuals with a request that they review the materials produced under Step 3 and provide feedback in a phone interview or by email, indicating which approaches they felt would be most workable and valuable in Montana;
6. Analyze and summarize feedback; revise work plan if appropriate
7. Re-circulate collected and summarized feedback to the individuals contacted through Step 5 to elicit further comments or suggestions;
8. Submit needs assessment document to the GIO, and a memo to the GIO, state GIS Coordinator and Council reporting on results of assessment.

Step 7 was modified due to time constraints. Instead of recirculating feedback to everyone consulted, results of the interviews, discussions, and exchanges were summarized and shared with members of the Land cover I-Team, which met on January 17, 2008.

RESULTS

To determine what land cover and land use layers were being used in other states, we ran internet searches using the terms "[State name] land cover land use map" and "[State name] GIS land cover land use." When these terms yielded no result, we substituted [State name] vegetation mapping. These combined searches produced statewide land cover map results for every state except Alaska, where statewide mapping is still incomplete (Table 1). We also contacted Natureserve and Heritage Programs in the western region to discuss new or proposed mapping initiatives that our search might not have found.

TABLE 1, CONTINUED STATE LAND COVER MAPS, CLASSIFICATIONS, AND SOURCE IMAGE RESOLUTION			
State	Year	Classes	Image resolution
Nebraska	2005	Agricultural land use (partial); land cover based on 1993 GAP	30m
Nevada	2004	109 natural classes, 125 total from SW ReGAP project	30m
New Hampshire	2001	NLCD/Anderson, including 10 wetland subclasses	30m
New Jersey	2005	NLCD/Anderson	30m
New Mexico	2004	109 natural classes, 125 total from SW ReGAP project	30m
New York	2005	NLCD/Anderson	30m
North Carolina	1997	NLCD/Anderson	30m
North Dakota	2001, 2002, 2004	2001 NLCD, 2002 Cropland cover, 2004 GAP	30m
Ohio	2002	GAP/ecological systems	30m
Oklahoma	2004	Gap/Ecological systems	30m
Oregon	1999	GAP/ecological systems	30m
Pennsylvania	2001	NLCD/Anderson	30m
Pennsylvania	2001	NLCD/Anderson	30m
South Carolina	1993	GAP, 27 land use/land cover categories	30m
South Dakota	2002	GAP, 35 land cover classes	30m
Tennessee	1997	GAP/NLCD, 11 aggregated classes	30m
Texas	2005(partial)	Anderson/NLCD	30m
Utah	2004	109 natural classes, 125 total from SW ReGAP project	30m
Vermont	2002	9 classes, with 1-9 subclasses, based on Anderson classification system	30m
Virginia	2005	NLCD/Anderson	30m
Washington	2002	Anderson NLCD	30m
West Virginia	2001	Anderson/NLCD with National Wetland Inventory converted to raster	30m, 1m
Wisconsin	1998	9 classes, with subclasses	30m
Wyoming	1996	GAP; reGAP to be complete in 2008	30m

TABLE 1. STATE LAND COVER MAPS, CLASSIFICATIONS, AND SOURCE IMAGE RESOLUTION

State	Year	Classes	Image resolution
Alabama	2007	71 classes (Natureserve ecological systems) from SE Regional ReGap project	30m
Alaska		No statewide land cover land use map	
Arizona	2004	109 natural classes, 125 total from SW ReGAP project	30m
Arkansas	2004	6 broad classes; agriculture and urban have subclasses	30m
California	ongoing, rotating	10 lifeforms, and multiple classes at alliance level, based on CalVeg	30m
Colorado	2004	109 natural classes, 125 total from SW ReGAP project	30m
Connecticut	2001	11 classes, both land cover and land use	30m
Delaware	2004	7 classes, with Anderson subclasses	30m, 1m
Florida	varies	Varies; mostly Florida DOT land use land cover codes	1m
Georgia	2005	13 land cover-land use classes after NLCD	30m
Hawaii	2006	GAP	30m
Idaho	1996-98	Gap, with 82 classes; reGap underway	30m
Illinois	2002	5 classes, each with 3 to 7 subclasses	30m
Indiana	1999	Based on NLCD	30m
Iowa	2002	17 LCLU, including CRP and grazed/ungrazed grasslands	30m
Iowa	2004	17 specific land cover classes, including CRP	15m, 30m
Kansas	2007-2008	5 LCLU, with 5 crop and 2 grassland subclasses	30m
Kentucky	2001	19 classes, following Anderson/NLCD	30m
Lousiana	2003	GAP	30m
Maine	2001	NLCD/Anderson, including 10 wetland subclasses	30m
Maryland	2005	NLCD/Anderson	30m
Massachussetts	2005	NLCD/Anderson, including 10 wetland subclasses	30m
Michigan	2003	NLCD/Anderson, total of 52 classes and subclasses	1m
Minnesota	2006 (partial)	Minnesota Land Cover Classification System (land cover, land use, cultural)	30m

TABLE 1, CONTINUED STATE LAND COVER MAPS, CLASSIFICATIONS, AND SOURCE IMAGE RESOLUTION			
State	Year	Classes	Image resolution
Nebraska	2005	Agricultural land use (partial); land cover based on 1993 GAP	30m
Nevada	2004	109 natural classes, 125 total from SW ReGAP project	30m
New Hampshire	2001	NLCD/Anderson, including 10 wetland subclasses	30m
New Jersey	2005	NLCD/Anderson	30m
New Mexico	2004	109 natural classes, 125 total from SW ReGAP project	30m
New York	2005	NLCD/Anderson	30m
North Carolina	1997	NLCD/Anderson	30m
North Dakota	2001, 2002, 2004	2001 NLCD, 2002 Cropland cover, 2004 GAP	30m
Ohio	2002	GAP/ecological systems	30m
Oklahoma	2004	Gap/Ecological systems	30m
Oregon	1999	GAP/ecological systems	30m
Pennsylvania	2001	NLCD/Anderson	30m
Pennsylvania	2001	NLCD/Anderson	30m
South Carolina	1993	GAP, 27 land use/land cover categories	30m
South Dakota	2002	GAP, 35 land cover classes	30m
Tennessee	1997	GAP/NLCD, 11 aggregated classes	30m
Texas	2005(partial)	Anderson/NLCD	30m
Utah	2004	109 natural classes, 125 total from SW ReGAP project	30m
Vermont	2002	9 classes, with 1-9 subclasses, based on Anderson classification system	30m
Virginia	2005	NLCD/Anderson	30m
Washington	2002	Anderson NLCD	30m
West Virginia	2001	Anderson/NLCD with National Wetland Inventory converted to raster	30m, 1m
Wisconsin	1998	9 classes, with subclasses	30m
Wyoming	1996	GAP; reGAP to be complete in 2008	30m

This initial search revealed that most states use 30m Landsat imagery as the basis for mapping, with the Anderson et al. (1976) classification scheme being the most widely used. This classification, which is also the basis of the National Land cover Dataset (NLCD), is a hierarchical system that moves from broad Level I life form classes (e.g. forests) to specific Level IV vegetation alliances. Although some states have classified land cover at the greatest level of detail, most publicly-available data is highly generalized.

A few states use color infrared imagery or true color aerial photography as the basis for their classifications. West Virginia uses a hybrid approach; most land cover classes are derived from 30m Landsat imagery, but high resolution National Wetlands Inventory maps (from orthoimagery) have been rasterized and incorporated into the statewide land cover layer. Michigan uses high-resolution photography to map land use and land cover at Level IV, as does Delaware.

In over a dozen states, GAP Analysis maps are the only widely available statewide land cover coverage, or the most recent. Several states have adopted GAP maps as their authoritative land cover layer, although they frequently aggregate GAP classes into Anderson Level I life form classes.

In general, land cover mapping across the United States displays little consistency. In most cases, funding came from federal agencies, or through larger, regional and national projects (the National Land cover Dataset, GAP and ReGAP, the Coastal Change Analysis Program). Responsibility for land cover mapping sometimes lies with state government, sometimes with academic institutions, and sometimes with federally-sponsored consortia. Delivery of map products is typically through data downloads, often broken into county-based or region-based units because of file size. A few states have interactive map applications that tie land cover to other map layers like transportation or roads; some others use image servers for delivery.

With this information in hand, we began contacting decision-makers and theme end users in federal, state, and local governments, non-profits, universities and private enterprise. Because of time and budget limitations, we used a targeted survey approach, asking key contacts to suggest other contacts who they thought would be interested in or knowledgeable about the subject. A list of all the people who were contacted for this survey can be found in Appendix A. For the most part, interviews were open-ended to encourage broad sharing of ideas. When possible, we held face-to-face meetings; in other cases, we had phone conversations or exchanged emails. In each case, we explained to participants that the goal of these conversations was to 1) identify the purposes for which land cover layers are/might be used; 2) determine the issues and challenges raised by those purposes; and 3) compile a list of needs and features that participants would like have in a land cover layer.

1. Identification of purposes for land cover. The comment received most often was "one size does not fit all." Most users could not imagine a single land-cover product

that would meet their needs and everyone else's too. Some of the identified needs were: land cover classification that would allow modeling of watershed-level impacts; data that would support habitat mapping; land cover classifications that would help determine suitability for building; identification of sensitive areas like riparian/wetland areas; determination of floodplain extent; identification of conservation targets; predictive modeling of areas where important species may be located; water conservation planning based on irrigated vs. non irrigated uses; energy facility and infrastructure siting; block management planning; and targeted real estate acquisitions for conservation, development and mitigation.

Most users were receptive to the idea of a hierarchical, scalable product with added, user-suggested attributes that would allow aggregation, analysis and alternative displays.. More experienced GIS users wanted a product they could adapt for their own use, and many wanted a way to feed back corrections, modifications, and refinements. Resource managers emphasized the need for interpretive materials that would guide them in the application of the maps; for example, they were concerned that they would not understand what the mapping units represented within the context of land management decisions unless there was a field guide or key.

2. Issues and challenges . Several separate groups of issues and challenges were identified during our discussions.

a) Evaluation of existing LC Datasets. The most commonly used statewide digital products in Montana are the National Land cover Dataset (2001), the GAP (1998), and the various SILC products produced by the Wildlife Spatial Analysis Lab at U of M. ReGAP is complete for most of Montana, with the remainder scheduled for 2008; Landfire (a GAP-based product) will be out in 2009. Although partial ReGAP datasets are available, most users had not seen them. The Forest Service is still completing its VMAP GIS layer. Other smaller areas are covered (sometimes in more detail) by individual datasets (e.g. Glacier National Park, the Centennial Valley, etc). There are issues associated with all these datasets. When we asked users about their experience with the existing datasets, they voiced similar concerns:

- Completeness. Many of the datasets do not cover the whole state, or do not cover the user's area of interest.
- Accuracy. Users noted that both the original GAP and the current NLCD generally identified areas that were different from adjacent areas, but often classified them incorrectly. For example, in the 2001 NLCD, alfalfa fields in coulees are sometimes classified as wetlands.
- Precision. In the original GAP and the 2001 NLCD, the boundaries of discrete land cover types are sometimes inaccurate. For example, in the NLCD, boundaries between grasslands and shrublands often don't match to what is on the ground. Users also noted that linear features like woody draws and riparian areas were often missed.
- Detail. Users concurred that one shortcoming of almost all land cover products is the 30m resolution, which offers insufficient detail for some

purposes. This was raised repeatedly in the context of wetland and riparian areas.

Currency. Most datasets are based on imagery which is 5 or more years old, and more recent major landscape modifiers (development in the valleys, wildfires, oil and gas development) aren't reflected.

b) What would be needed for ReGAP to work as a data model/basis for the maps? Because ReGAP offers the most recent and detailed land cover mapping, we asked users who were familiar with earlier GAP products if they thought it would be suitable as the basis for a Montana-specific map. No one expressed unqualified support for ReGAP, even if they had not yet seen the product. Responses fell into several broad categories.

- There would have to be some way to make corrections.
- A product based on ReGAP would need to be crosswalked/ crosswalkable to other systems (FWP Comprehensive Strategy, TNC ecoregions, National Vegetation Classification standard, USFS, etc). This could be handled by adding attributes that would allow users to display alternative classification schemes.
- It would need to have aggregated classifications for easier display, but retain the original, more detailed classifications too. Users objected that the public version of the first GAP had fewer land cover units than the version that was originally produced. However, they noted that it would be almost impossible to make sense of a map with 82 land cover units if large areas were being displayed. Therefore, it would be better to have a series of aggregated classifications at the statewide level, while retaining the original units for display when examining small areas.
- Some users also wanted a hierarchical classification that will allow it to nest more refined classification levels (alliances or associations) for areas where those had been mapped.
- Many users stressed the need for documentation to make the product workable and understandable (ReGAP is based on Natureserve ecological systems, which are described generally but not specifically for Montana, and do not contain habitat, conservation, or management information).
- Vegetation ecologists and botanists recommended that the map units should somehow reflect FGDC standards (the National Vegetation Classification standard, or NVC) for vegetation mapping; ReGAP's map units, ecological systems, are not part of the NVC, although they can be nested within it.
- Most non-GIS users stressed the need for training and outreach to ensure understanding of appropriate uses and limitations.

c) What methods would need to be defined and adopted? Following up on the first question, we asked interviewees what they imagined would be necessary to make the map valuable over time. Responses fell into six broad categories:

- Procedures and protocols for refinement, when more detailed info exists for an area.
- Procedures and protocols for correction, when pixels are incorrectly located or classified.
- Procedures and protocols for crosswalking to other classification systems.
- Standards for interpretation/classification/interpolation during updating, correction, refinement.
- Standards and minimum requirements for data collection, submission and archiving to ensure an interactive and dynamic product
- Methods and procedures for integrating other framework layers that have more detail on some land cover types (wetlands, agricultural land classifications, etc.)

d) What would be the best means of distribution? This question elicited strong responses. Experienced GIS users wanted distribution systems with minimal "bells and whistles," generally favoring a download site or an image server. Resource managers expressed a strong preference for a web service or application where data could be displayed and examined against other biological and physical landscape information. Interviewees who were familiar with the Natural Heritage Program Tracker application were eager to see a land cover layer added to that website.

3. Desirable needs and features. This question asked users to note other needs. The areas most frequently identified were:

- The need for rapid response to large-scale landscape modifiers (fire, disease and insect outbreaks, major land use change). Even if individual pixels were not changed, users wanted some sort of warning, such as a polyline boundary for fire areas, which would alert them that the underlying land cover might have changed.
- The need for consistency. The corollary of rapid response to change was the need to keep the layer constant over time. GIS users were especially concerned that the raster layer would change so often that no one would ever be able to finish an analysis. A yearly update schedule was acceptable to most respondents.
- The need for detail for riparian/wetland areas, sagebrush, and weeds. Resource managers who use GIS in their decision making area are aware of the difficulty of accurately depicting wetland and riparian areas in a 30m raster layer, and in accurately classifying them from satellite imagery in the first place. Similarly, land agencies and biologists working with sagebrush emphasized how important it was to incorporate fine-scale sagebrush mapping efforts. Resource managers also expressed a desire for effective weed mapping aspart of the land cover layer.
- Need to open and maintain links to other land cover work. Several users suggested that any web site or web application should have links to other programs and projects (universities, private GIS companies, Landfire, GAP, Natureserve, etc) where additional data could be found.

- Need to archive data, e.g. plot level data that could be the basis for new or improved classification. Agency users and image analysts were especially enthusiastic about a vegetation data archive where data could be submitted and retrieved, either to supplement the GIS layer or as training data for new image classification. Resource managers wanted to be able to see new plot data (i.e. data that was more recent than that used in ReGAP classification) displayed as a point layer against a web-based map, with the ability to open attribute tables, and download the data.

CONCLUSIONS AND NEXT STEPS

Everyone we spoke to expressed enthusiasm for a land cover product that would support, encourage, and reflect user updating and input. This seemed to be the single best solution for dealing with issues of inaccuracy, misclassification, dated information, and lack of detail. Similarly, no one was confident that a single map legend could satisfy everyone, but respondents were supportive of the idea that attribute fields could be added to support crosswalking and facilitate analysis. Several users suggested other attributes that could add value to the ecological systems classifications used in ReGAP: conservation significance; susceptibility to climate change; suitability for residential, industrial or transportation development; habitat value for species of concern, etc.

We also concluded that there is a genuine need for two separate delivery mechanisms, one a web-based application and the other a simple image server. While resource managers are increasingly familiar with GIS and its capabilities, they want a quick and easy way to interact with multiple data layers.

Our first grant proposal, submitted to MLIAC in 2007, centered on hiring a coordinator who would do a detailed needs assessment. These consultations and interviews have led us to conclude that the better approach is to focus on getting a fully functional land cover layer out as soon as possible in both web-based and image server formats, and to work with advisory committees of users and decision-makers to identify needs and build new functionality as we go along.

Based on this preliminary needs assessment, we will submit a funding proposal that responds to the issues, concerns and needs that have been identified.

Appendix A: Individuals consulted as part of this assessment (an asterisk indicates GIS is primary work focus):

Lydia Bailey, Montana Fish, Wildlife and Parks, Helena*
James Colgrove, Montana Fish, Wildlife and Parks, Helena
Doris Fischer, Montana Fish, Wildlife and Parks, Sheridan
Janet Hess-Herbert, Montana Fish, Wildlife and Parks*
Jeff Herbert, Montana Fish, Wildlife and Parks, Helena
Travis Horton , Montana Fish, Wildlife and Parks
Adam Messer, Montana Fish, Wildlife and Parks, Helena*
Joe Weigand, Montana Fish, Wildlife and Parks, Helena

Greg Mullen, Department of Justice, Helena

Jane Horton, Montana Department of Environmenal Quality, Helena*
Craig Jones, Montana Department of Environmental Quality, Helena*
Tom Ring, Montana Department of Environmental Quality, Helena
Linda Saul, Montana Department of Environmental Quality, Helena
Chris Yde, Montana Department of Environmental Quality, Helena

Steve Armiger, BLM Dillon
Laurie Brinn, BLM Dillon*
John Carlson, BLM Malta
Jay Parks, BLM Billings
Mike Philbin, BLM, Billings
Gayle Sitter, BLM Billings
Nora Taylor, BLM, Billings

Beth Hahn, U.S. Forest Service, Missoula
Mark Jensen, U.S. Forest Service, Missoula
Skip Kowalski, U.S. Forest Service, Missoula
Mary Manning, U.S. Forest Service, Missoula
Steve Shelly, U.S. Forest Service, Missoula

Pete Husby, Natural Resource Conservation Service, Bozeman
Cathy Maynard, Natural Resource Conservation Service, Helena
Jon Siddoway, Natural Resource Conservation Service, Bozeman
Dawn Wickum, Natural Resource Conservation Service, Chester

Sibyl Govan, Montana State Library, Helena*
Jim Hill, Montana State Library, Helena (retired)

Larry Urban, Montana Department of Transportation, Helena

Jerry Rodriguez, U.S. Fish and Wildlife Service, Medicine Lake

Michael Downey, Montana Land Reliance, Helena
Tom Hinz, Montana Wetlands Legacy, Bozeman
Steve Hoffman , Audubon, Helena

Brian Martin, The Nature Conservancy, Helena
Amy Pearson, The Nature Conservancy, Helena*
Ken Sambor, Northern Great Plains Joint Venture, North Dakota
Bob Sanders, Ducks Unlimited, Helena

Solomon Dobrowski, University of Montana, Missoula*
Will Gustafson, University of Montana, Missoula*
Melissa Hart, University of Montana, Missoula*
Dave Naugle, University of Montana, Missoula
Roland Redmond, University of Montana, Missoula(retired)
Karen Shelley, University of Montana, Missoula
Michael Sweet, University of Montana, Missoula*

Curtis Keuer (consultant), Three Forks
Lynn Bacon (consultant), Bozeman
Ken Wall (consultant), Missoula
Joe Glassy (consultant), Missoula
Gloria Flora (consultant), Helena

Renee Van der Hoven, Ravalli County
Tammy Crone, Gallatin Local Water Quality District, Bozeman
Laura Hendrix, Association of Floodplain Managers, Hamilton

Sue Ball, Confederated Salish and Kootenai Tribes, Polson
Mary Clare Weatherwax, Blackfeet Tribe, Browning

George Jones, Wyoming Natural Diversity Database
Jimmy Kagan, Geographic Enterprise Office, Oregon
Todd Keeler-Wolf, California Department of Fish and Game
Chris Murphy, Idaho Fish and Game
Eric Peterson, Nevada Natural Heritage Program
Marion Reid, Natureserve, Colorado
Joe Rocchio, Washington Department of Natural Resources
Kevin Ryan, Landfire Coordinator, Missoula